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Original Article

Current Situation of Human Resources in the Semiconductor Industry in Vietnam and Experiences From Taiwan

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Abstract*: This article researches the current situation of human resources in the semiconductor industry in Vietnam and lessons on policies to solve the problem of human resource shortage in Taiwan. The current situation of human resources in the semiconductor industry in Vietnam is analyzed through a synthesis of articles and reports related to the current situation of the semiconductor industry, especially the industry's human resources. Research results show that the shortage of human resources in the semiconductor chip manufacturing industry is a difficult problem for countries around the world. Great powers like the US and leading countries in the industry like Taiwan and Vietnam are facing a shortage of human resources. The reason is that the semiconductor industry requires highly qualified human resources, but in reality, although the quality of training in Vietnam has achieved significant achievements, many limitations still exist. Training programs, professional qualifications, facilities... On the other hand, the article analyzes the current situation of human resources in the semiconductor industry in Taiwan through a case study of TMSC company - the leading corporation in Taiwan and the world in the semiconductor industry, thereby providing some experiences for Vietnam, including: Focusing on training and attracting high-quality human resources, creating favorable conditions and environment for FDI investors, implementing specialization... Based on that basis, the research team offers a number of policy implications to solve the problem of human resource shortage in the semiconductor industry in Vietnam.*

Keywords: *Current Status of Human Resources, Semiconductor Industry, Vietnam, Taiwan, Experiences.*

I. RAISING THE ISSUES

Statistics show that, from 2001 to the present, the global semiconductor industry has experienced remarkable growth, reaching a value of nearly 800 billion USD by 2023. The trend of creating high-tech application fields like artificial intelligence, cloud storage, big data, self-driving vehicles, and the digital shift has emerged as the primary factor propelling the semiconductor sector's future growth as science and technology advance. (Bui Huy Hai, Tran Thi Thu Huong, 2024)

The semiconductor industry plays an important role and profoundly impacts modern life. Semiconductor products are commonly used in the industries of consumer electronics, modern automobiles, telecommunications, information technology, energy networks, traffic management systems, healthcare, defense and security. Semiconductor chip technology is the foundational technology and prerequisite for many emerging technologies, such as artificial intelligence (AI), quantum computing, smart cars and the Internet of Things (IoT). It is the driving force for the future growth of the semiconductor industry. This industry is one of the largest in the world, with a market value currently reaching about 600 billion USD and increasing. The current global semiconductor value chain is very complex because it includes many steps from raw material production to finished product production and distribution, divided into 3 main stages: design, manufacturing and packaging. Economies such as the United States, China, Korea, Japan, Taiwan and some EU countries play a leading role in this supply chain and have become centers of the semiconductor industry. (Bui Huy Hai, Tran Thi Thu Huong, 2024)

In Vietnam, manufacturing and business enterprises in the semiconductor industry are still 100% dependent on the supply of semiconductor chips from foreign countries. Only Viettel High-Tech Industry Corporation and FPT Semiconductor Joint Stock Company participate in the semiconductor chip design stage in Vietnam. Foreign-invested companies mostly carry out IC design, assembly and testing processing stages. This step creates the lowest added value in the global semiconductor value chain. (Bui Huy Hai, Tran Thi Thu Huong, 2024)

With the rapid development of the semiconductor industry, the need for capital and human resources is increasing, especially human resources with specialized skills and high quality. The problem of solving human resources for the semiconductor industry has become an urgent issue for countries around the world participating in each link of the global value chain of the semiconductor industry. From product design, R&D, processing and assembly... Thus, the shortage of human

resources is an urgent problem that needs to be solved, especially for a country like Vietnam, which has a significant growth rate in the semiconductor industry. Because the semiconductor industry in Vietnam is increasingly developing, overall, Vietnam mainly participates in the global semiconductor value chain at the assembly and processing stage while researching, designing and developing products that create high-added value. However, the workforce with high professional qualifications in this field is still scarce in Vietnam and globally. Research on the current situation of human resource shortage in the semiconductor industry to assess the level of shortage in quantity and quality in order to have appropriate and practical solutions to the research problem. Although the US is also the leading power in the field of semiconductors, the research team chose to analyze and point out lessons that Vietnam can apply from Taiwan's practices because Vietnam and Taiwan have certain similar characteristics. Taiwan is the world's leading country in the semiconductor industry. Although production has achieved significant achievements, the problem of human resource shortage is still a difficult problem, and Taiwan is and has been. There are policies that Vietnam can learn from to face the scarcity of human resources in the semiconductor industry. Thereby, the research team synthesizes lessons learned from Taiwan's practice and proposes a number of policy implications combined with practical solutions to solve the problem of human resource shortage in the semiconductor industry in today's globalisation context.

II. OVERVIEW OF THE WORLD'S SEMICONDUCTOR INDUSTRY

Labor shortage is considered the biggest global problem facing the semiconductor industry (Kathryn Ackerman, 2023). There are many studies and articles about the semiconductor industry. However, they generally focus on human resource issues, human resource shortages, and the negative impacts on the national, regional, and global economies. The US semiconductor sector is expected to experience a 70,000–90,000 job shortage in the upcoming years. The Japanese Semiconductor Industry Association projects that this industry will have a shortage of around 1,000 qualified workers annually during the next ten years. In the meantime, more skilled labor is needed due to the "race" to construct semiconductor plants in Japan. The Korean Ministry of Education established a "10-year roadmap" for educational institutions to train 150,000 bachelors in the semiconductor industry to address the country's workforce deficit. "Semiconductor universities" are the designation given to certain universities. Every region is part of a national network and has its own semiconductor study center (dainam.edu.vn).

The semiconductor industry in Taiwan plays an important role in the economy but is currently facing a shortage of human resources, seriously affecting the industry's productivity and development potential. According to Focus Taiwan, the value of the semiconductor industry is forecast to reach 160 billion USD in 2024, an increase of 15.4% compared to 2022. Although the semiconductor industry in Taiwan is thriving, Taiwan is still facing the problem of a shortage of human resources, up to 130,000 engineers. (Cheng Ting-Fang and Lauy Li, 2022).

The semiconductor industry plays an important role in Taiwan's economic growth (accounting for 15% of GDP); the shortage of human resources has a negative impact on economic growth. Malaysia is a well-established country at the forefront of the semiconductor industry with assembly, testing and packaging facilities. As the country attracts more interest from global chipmakers, "the hunt for Taiwanese talent in Malaysia is a positive development. (restofworld.org, 2024)

The American Semiconductor Industry Association (SIA) affirms that if Taiwan is unable to produce chips for 1 year, the electronics industry's revenue will decrease by nearly 500 billion USD. Besides Taiwan's importance in the global semiconductor value chain, international competition among semiconductor companies in Taiwan is also a driving force behind the development of Taiwan's capital market. (Lam Le and Chong Pooi Koon, 2024).

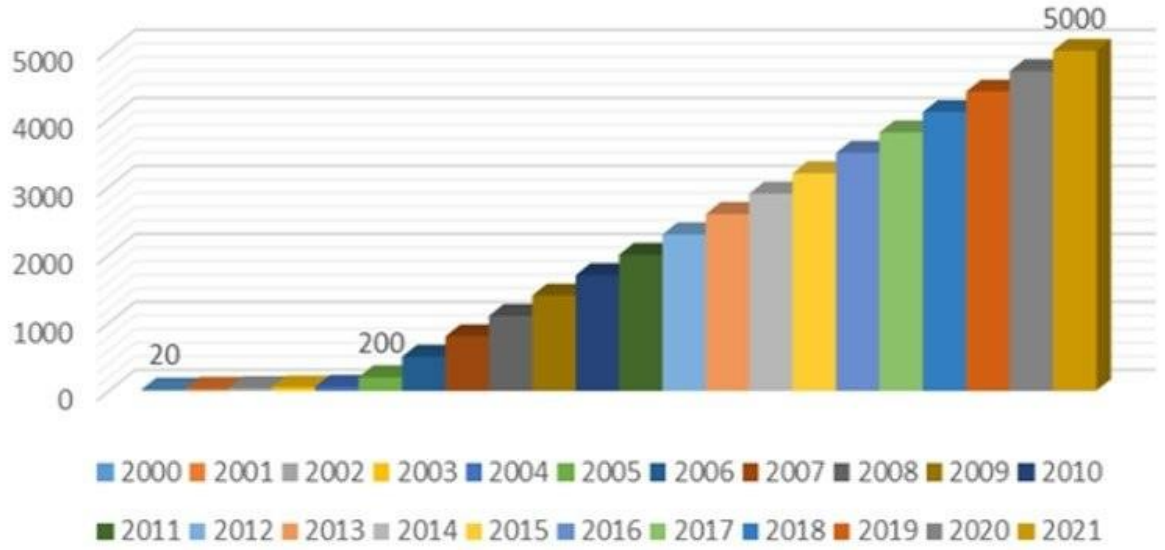
18 states in US states are the locations of major semiconductor facilities, companies and businesses. Semiconductors are an important input for more than 300 important industries of the economy, especially the electronics industry, accounting for more than 26 million American workers. Because semiconductor sector workers are so productive, their average yearly salary in 2020 will be $170,000. Over 277.000 people are directly employed by the semiconductor sector in 49 states in high-paying R&D, design, and production roles. The industry also sustains 1.6 million additional American jobs. The average annual increase in temporary employment in the United States when new semiconductor manufacturing plants are built between 2021 and 2026 is $24.6 billion. Number of new employment created in the US economy, of which 42.000 would be in the semiconductor sector directly. The amount of jobs that the federal investment program will help the US semiconductor sector achieve; by 2027, the program will have a total employment impact of 2.13 million jobs. (Inphographic, 2024)

Madeleine Ngo (2023) points out the current situation and the impact of the shortage of human resources in the semiconductor industry on the US economy. In particular, research by Deloitte shows that the shortage of human resources in the US semiconductor industry could reach 90,000 people in the coming years. This situation leads to serious economic consequences for the US, such as loss of revenue and job opportunities for Americans. The supply chain is vulnerable to semiconductor chip shortages, hindering dozens of industries, causing sudden price increases in the auto industry and, hundreds of billions of dollars in lost revenue, and increased national security risks in the US-China chip war. (Madeleine Ngo, 2023).

III. CURRENT SITUATION OF HUMAN RESOURCES IN THE SEMICONDUCTOR INDUSTRY IN VIETNAM

Vietnam has a relatively skilled team of engineers with an average career age in the golden age, with an average number of years of experience of about 5 years. This is considered a huge advantage for Vietnam because this age group is the age with the most creativity and contributions to the IC industry.

Figure 1. Estimated number of Vietnamese chip design engineers in the period 2000-2021



Source: *Vietnam Microchip Community (Nguyen Thanh Yen, 2022)*

In Vietnam, there are many establishments, universities and research units in the field of engineering, such as Hanoi and Ho Chi Minh National Universities, Hanoi University of Science and Technology, with more than 40% of students graduating in engineering are young workers with high technical knowledge. In addition, Vietnam also has large enterprises with resources and willingness to cooperate in developing the semiconductor industry, such as Viettel, VNPT, FPT, and CMC. (Tran Vu Manh, 2024)

However, compared to the human resource needs of the semiconductor industry in the world in general and in Vietnam in particular, Vietnam's human resources are still lacking in both quantity and quality. In terms of quantity, the number of chip design engineers does not meet the needs of the industry. Regarding quality, there is a shortage of highly qualified engineers, chip design and other stages that require a high level of intelligence and science.

A) The shortage of human resources in the semiconductor industry in Vietnam

Vietnam currently has more than 40 companies and businesses specializing in circuit design with 5,500 chip design engineers, concentrated mainly in Ho Chi Minh City, accounting for more than 76%. Meanwhile, the semiconductor industry's human resource needs range from 5,000 to 10,000 engineers/year, but the ability to supplement this human resource is only about 20%. In the stages of semiconductor chip production, Vietnam focuses on the chip design stage, accounting for about 52%, while other stages, such as chip production, chip packaging, and testing, account for 48% but are still vulnerable. With a human resource of 5,500 engineers in the Vietnamese semiconductor industry, IC design accounts for the highest proportion, while other stages have very limited human resources. (Cao Tan, 2023)

Box 1. Viettel case

Viettel is one of two leading enterprises in Vietnam's semiconductor industry market. Viettel has strongly promoted research and development (R&D) activities since 2010 and has now built a team of more than 3,000 engineers. As for IC engineers, Viettel currently has about 50 high-quality engineers. For IC engineers, every year Viettel recruits with the goal of recruiting 20 - 30 people each year, but in reality, it only recruits more than 10 people each year. However, to achieve the number of 50 engineers, businesses must undergo many years of recruitment. Recruitment activities are relatively difficult when out of 10 applications, only 1 can be selected. The reason is that the semiconductor industry requires high-quality human resources, while most human resources do not meet recruitment qualifications.

According to a representative of Viettel Group, out of 50 high-quality engineers, 10 are from abroad, many of whom have worked at large companies. As for engineers recruited domestically, they can get lower-level jobs. For engineers trained in Vietnam to be able to perform higher stages requires a long process.
Source: *vov.vn (2024)*

B) Vietnam's efforts in building the current semiconductor industry workforce

According to statistics from the Ministry of Education and Training, the country currently has about 11 training establishments with training programs closely related to the semiconductor and microchip industry; 35 schools have training or conversion programs from career groups related to semiconductors and microchips. Currently, a number of fundamental training majors to develop IC design in Vietnam are provided by large universities such as Hanoi University of Science and Technology, Ha Noi national university, Ho Chi Minh City National University has appeared in world rankings such as Electrical - Electronics Engineering group; Mechanical, Aerospace and Manufacturing Engineering; Computer Science and Information Systems; Technology; Mathematics has a ranking position from 301-550 in the world (according to the rankings of the QS Organization). (Viet Ha, 2023)

Box 2. Hanoi University of Science and Technology - Pillar member of university alliance training in the field of semiconductor technology

October 2023, Associate Professor. Huynh Quyet Thang - Director of Hanoi University of Science and Technology - signed a Memorandum of Alliance Cooperation on developing high-quality human resources in the semiconductor chip industry with leaders of Ho Chi Minh City National University, Hanoi National University, Da Nang University and Posts and Telecommunications Institute of Technology. Associate Professor. Huynh Quyet Thang commented that the signing of cooperation to form an alliance between educational institutions on human resource training for the semiconductor chip industry opens up: 1. Opportunities; 2. Breakthrough solution: Special regulations for training and research; 3. Global; 4. Create Vietnam's semiconductor industry.
Source: *Hanoi University of Science and Technology (2024)*

Vietnam has an abundant, young human resource with a good foundation in mathematical thinking, and highly qualified human resources are constantly increasing. The fields of engineering technology, especially the fields of information technology, automation, electronics, and computer engineering, are attracting the attention of young generations. These are fields related to different stages in the semiconductor industry. Therefore, domestic training facilities need to have training plans and continue to further improve the quality of human resources to take advantage of this advantage. According to statistics, Hanoi National University has about 20 training majors related to semiconductors and microchips, with about 1,500 students/year. Hanoi National University has also developed semiconductor and IC research groups, which include chip design, manufacturing, and application product development. At the same time, investing in equipment and laboratories such as SISlab microchip design (more than 40 billion since 2006), Clean room, micro-fabrication, materials (more than 100 billion), including the Nano and Energy Center (since 2011) and the Key Laboratory of Micro and Nano Technology (2016). (Viet Ha, 2023)

Ho Chi Minh City National University has 4 training schools related to IC design, including Polytechnic University, University of Sciences, University of Information Technology and University of International Studies. The scale of related industries accounts for 18.7%, and nearby industries account for 5.8% of the total training scale, with over 3,500 targets/year. In particular, the scale of specialized training in IC design has about 200 students and 50 postgraduate students each year. The advantage of Ho Chi Minh City National University is that it has a relatively complete, quality and experienced teaching and research team, especially in engineering and technology fields. There are many strong research groups in the field of information technology and several in the field of IC design. In particular, the IC Design and Training Center, established in 2005, affiliated with Ho Chi Minh City National University, has designed and manufactured 8-bit SG8v1 and 32-bit VN1632 microprocessor chips; Designed and manufactured IP cores for data security applications. Ho Chi Minh City National University's goal in 2023-2030 is to train 1,500 engineers, bachelors, 500 masters and 15,000 IC design certificates; Build 4 training laboratories and 2 specialized laboratories; establish Semiconductor Research Institute. (Viet Ha, 2023)

With the same strength in training in the fields of science and technology - Hanoi University of Science and Technology currently has 7 majors and 2 specialized training majors in IC, with more than 3,000 targets per year. Hanoi University of Science and Technology has implemented training and research in the following stages: design, production, and application development. The laboratory has been fully equipped with equipment to produce and test semiconductor components. Along with that, Hanoi University of Science and Technology has good student input quality, a large alumni team, and many people currently working in microchip businesses. (Viet Ha, 2023)

Danang University currently has 7 training programs related to semiconductor ICs, with about 1,000 annual enrollment quotas. From now to 2025, Danang University plans to open 2-3 new specialized training majors in the field of microelectronics and circuit design, starting to enroll students in 2024 with about 100-150 students/year. At the same time, strengthen human resources and cooperate in inviting domestic and international experts and scientists to participate in teaching and research; Review and update training programs (nearby industries) to add conversion modules related to the field of microchips and semiconductors; Organize short-term training courses (3-6 months) to grant certificates. Entering the period 2025-2030, Danang University aims to promote investment in upgrading laboratories, create conditions for lecturers to participate in prestigious international conferences, and Cooperate in research and manufacturing of prototypes with a number of foreign universities and research institutes. In addition, Da Nang University will establish a Semiconductor Circuit Research Center, combining "managers - businesses - schools" and establish an international semiconductor circuit engineer training network... (Viet Ha, 2023)

C) Difficulties and challenges in building human resources for the semiconductor industry in Vietnam

The semiconductor industry is not a completely new training industry, and there are a number of large universities such as Polytechnic University, and Ho Chi Minh City National University. Ho Chi Minh City, and Hanoi National University... have been implementing training, but the number of students enrolled and graduated so far is still very low, partly due to career opportunities as well as unsatisfactory training quality of business requirements. In addition, it is difficult to recruit lecturers who specialize in the semiconductor industry, and they need an understanding of the university's philosophy. The reason is that the information technology field is growing rapidly and offers attractive remuneration, making it difficult to attract high-quality lecturers. In addition, the cost of investing in equipment and facilities to meet the training needs of the semiconductor industry is also a challenge. (Bao Binh, 2024)

Because the labor market in the field of semiconductor chips is just beginning to form, mainly in potential form, the biggest challenge is how to attract students to study these majors and improve the quality of training. Meet the strict requirements of investment businesses (mainly from the US). (Vu Hai Quan, 2024)

Difficulties in building human resources for the semiconductor industry arise in human resource training programs. The training program does not have an IC design industry code, lacks training programs and training courses and lacks policies to support lecturers and experts as well as attract good students. Besides, Ho Chi Minh City National University still lacks laboratories for training and in-depth research. There is no IC design research center connecting businesses, universities, experts, manufacturing practices, testing and testing. (Viet Ha, 2023)

Hanoi University of Science and Technology also has some difficulties and challenges in current training: In-depth facilities for semiconductor chips lack software, testing and manufacturing machinery; Learning materials and experiments are not synchronized; The number of lecturers/students is low, and the number of students studying the right major is small; Most students choose to study software.

Thus, there are 4 difficulties and challenges in building human resources for the semiconductor industry, which are: (i) The problem of attracting learners, (ii) Training program, (iii) the lack of leading experts in the industry, (iv) Lack of a system of IC design laboratories so that shared software can be shared.

IV. LESSONS LEARNED FROM TAIWAN AND SOME POLICY IMPLICATIONS

A) Experiences from Taiwan

a. Contact case study of TMSC Group

Morris Chang, founder of TSMC Group, a leading enterprise in Taiwan's global semiconductor industry, sees that the key to success lies in the quality of human resources - with a very low turnover rate among skilled employees. Realizing the opportunity coming from the other side of the Pacific, Japan and Korea have almost no difficulty finding high-quality human resources and have become two powerful semiconductor powers. Morris Chang believes that the future of the semiconductor chip manufacturing industry will lie in Asia. (Pham Vu Thieu Quang, 2024)

Most semiconductor companies still follow the integrated device manufacturing (IDM) model, with the entire design, manufacturing, and sales process performed under a single company. Morris Chang spotted a preparatory trend across the industry - most companies, especially in the US, would focus solely on chip design and outsource manufacturing to reduce costs. Mr. Chang's awareness also came at the right time when Taiwan began to enter the later stages of its economic miracle, transforming from a heavy industrial economy that used a lot of cheap labor to a high-tech economy. At this time, the semiconductor industry in Asia was developing strongly in Japan, but the two followers, Korea and Taiwan, were increasingly receiving attention from foreign businesses. Foreign investments began to flow into Taiwan as a cheap labor destination, but policymakers began to realize the major problem of maintaining a high-tech industry that relied too heavily on FDI.

When building production facilities, foreign businesses will have to train local human resources to operate the factory and production process. However, foreign corporations are less willing or able to transfer the skills needed to innovate processes or invest in research and development activities. They are cautious about transferring know-how or technology that could threaten their core capabilities, especially if these skills could be used by local competitors. Some scientific studies on the impact of FDI in the technology sector at that time also said that innovation activities are something businesses only have experience doing inside the company, and it is difficult for them to teach human resources or companies ways to follow. (Pham Vu Thieu Quang, 2024)

Taiwan's approach to promoting innovation in the high-tech industry focuses on developing indigenous research activities, building a comprehensive domestic technology ecosystem, and attracting Taiwanese people from abroad to advise and support. Instead of allowing large enterprises to completely control the semiconductor field, from the beginning, Taiwan has tried to diversify into many different semiconductor fields to ensure that if one "big guy" dominates an area, small and medium enterprises can still operate in other sectors. (Pham Vu Thieu Quang, 2024)

Taiwan also promotes cooperation between semiconductor enterprises, leading universities, and research institutes, understanding the key role of developing an indigenous ecosystem for the semiconductor industry. Businesses and organizations will be able to coordinate more easily if they are geographically close, and if the government supports the development of facilities that can be shared between units, industry-wide operating costs will be reduced much lower. In that context, the Taiwanese government established Hsinchu Science Park in 1980, located near two leading technical universities and built to become a major semiconductor industrial park in this territory. The government also established two research institutes during the same period, ITRI (Industrial Technology Research Institute) and ERSO (Electronics Research and Services Organization). (Pham Vu Thieu Quang, 2024)

To address concerns about facilities and quality of life, the Taiwanese government has provided many financial and material incentives, along with low-cost housing, schools for children, and high-quality medical facilities.

TSMC has thrived on the approach of not competing with other companies in the market but instead approaching them as customers and pledging to reduce their operating costs if they choose TSMC. At the same time, specialization and focus on production technology helped TSMC catch up with Phillips, and by the late 1980s, when it began applying 0.8-micron technology, it was no longer dependent on Philips technology transfer. While collaborating with Philips, TSMC has also developed its own technological capabilities through strong R&D cooperation programs with ITRI, aiming to replace its dependence on Philips technology with its own research centers. This strategy has allowed TSMC to develop relationships in the local market, collaborate and develop the capabilities of domestic equipment and component suppliers, and invest heavily in R&D activities in Taiwan's human resource research and training centers.

In contrast to the vertical integration model proven successful by companies such as Samsung or Toshiba, Chang's decision to specialize in TSMC has vertically dispersed Taiwan's semiconductor industry. TSMC's success then set a precedent for the global semiconductor industry to split into many companies operating in many different stages, becoming an industry characterized by specialization. The rapid growth of the design sector has led to the rapid introduction of a new semiconductor technology, ASIC (Special Purpose Integrated Circuit). An ASIC is an IC designed for a specific application, and today, it is used everywhere based on need, from cell phones to portable machines and media. Taiwan consistently leads two of the three main stages of the semiconductor industry and is second only to the US in the design stage.

Today, fabless businesses can focus all their resources on developing a single specialized chip and submit orders to TSMC. In turn, this process innovation has also attracted many high-tech investments into design businesses in Taiwan, especially in the form of FDI, helping the design field in Taiwan increase by 22.4%. Times - in just 7 years, from 1986 to 1993. Therefore, in addition to TSMC and UMC focusing on manufacturing, Taiwanese companies today operate and have many successes in all three main stages of the semiconductor industry - design, production and assembly. (Pham Vu Thieu Quang, 2024)

B) Prospects for the semiconductor industry in Vietnam

Vietnam has made significant investments in ports, airports, and road infrastructure in order to assist the expanding semiconductor sector. Additionally, the Vietnamese government actively encourages investment in this field by providing tax breaks and other advantages to businesses that choose to locate there. In addition, Vietnam is developing more sophisticated facilities for producing semiconductors, with a number of new projects either planned or in the process of being built. Producing a range of goods, including memory chips and displays, Samsung Electronics' Ho Chi Minh City plant is one of the biggest semiconductor plants in Vietnam (wtocenter.vn, 2024)

a. Workforce and talent resources

Vietnam is a more affordable place to establish manufacturing than Taiwan because of its lower cost of living. It also boasts a sizable youthful, educated, and skilled labor force, which is crucial for the semiconductor sector. To entice major chip makers, Vietnam has spent billions of dollars building research, education, and workforce training facilities. Science and engineering are the fields in which over 40% of Vietnam's college and university graduates concentrate, making up a sizeable

share of the labor force. Vietnam's high ranking among the top 10 nations in terms of engineering graduates is evidence of this demographic advantage. However, Vietnam attracts talent from all over the world because of its reduced cost of living and the existence of major global firms in the semiconductor industry. This flood of talented people has aided in the industry's rapid growth and expansion. To aid in the growth of the semiconductor industry, the Vietnamese government has set up a variety of funds. For instance, the National Technology Innovation Fund (NATIF) was founded to fund research and development. The Vietnam-Korea IT Incubator (VKII) is another resource available in the nation for funding and assistance to businesses in the semiconductor sector. (2024, wtocenter.vn)

b. Geographical location

Vietnam is ideally situated for manufacturers wishing to capitalize on the rapidly expanding semiconductor industry in Southeast Asia, given its strategic location near the center of the continent. Vietnam's geographic advantage allows it easy access to the major semiconductor distribution networks in the globe, which pass through Korea, Japan, and China. (wtocenter.vn, 2024)

c. Raw materials for chip production

In terms of the supply chain of chip production materials, Vietnamese chip manufacturers still rely heavily on imported materials from other countries. Only two domestic enterprises, VHT and FPT, participate in chip design, while the majority of companies responsible for designing, assembling, and testing microchips are foreign-invested enterprises. But, Vietnam is also making great strides toward developing an internal supply chain for its semiconductor sector. The government has put in place a program to draw capital to sectors that assist in the manufacturing of chips, like the fabrication of electronic materials and components. Vietnam has also ratified a number of free trade agreements in an effort to lower trade barriers and make it easier for commodities and raw materials required for the manufacture of chips to be imported and exported. Vietnam also boasts a wealth of raw minerals and natural resources, including rare earths and silica sand. This gives Vietnam a special advantage in developing a more integrated supply chain. (wtocenter.vn, 2024)

C) Some policy implications

Firstly, microchip-related research and development issues and initiatives require special programs from the Ministries of Science and Technology and Information and Communications. We must decide which directions and uses for microchips—AI, IoT, telecommunications, 5G, and 6G chips, for example—to concentrate our energies on. The Ministry of Planning and Investment must make investments in university-based mixed laboratories. Collaboration between universities and industry is required to create the laboratory. We will connect university operations with commercial endeavours by locating laboratories there. Business concerns will be taught in schools. After completing their training, students will be prepared for employment right away. This training approach also aligns with the competencies and needs that companies require. Businesses can use human resources, particularly information learned in schools, to support their operations. In order to have premier universities, we also need to build our capacity for training and research.

Second, it is necessary to focus on training more specialized human resources in the semiconductor industry. The training process can be carried out both domestically and abroad, and it combines student exchange and education to optimize training effectiveness. In addition to new training, it is also necessary to focus on retraining people working in industries related to the semiconductor industry in order to shorten the time and ensure labor targets. This requires close coordination between ministries, branches, research organizations and universities. In addition, the government needs to support and encourage large universities in Vietnam to focus on professional research and develop high-quality human resources in this field. Semiconductor device research and manufacturing industries must also be invested in and developed, including circuit design technology, packaging-testing technology, laser technology, light-emitting diode technology, and receiver/emitter diode technology.

Third, long-term and sustainable solutions such as continuous training programs must be developed. Universities and colleges must design and implement in-depth training programs on semiconductor technology, including courses on circuit design, product quality management, manufacturing techniques and other new technologies, such as IoT AI in the semiconductor industry. In particular, it is necessary to focus on developing soft skills for students and trainees in addition to professional skills to improve learning and working efficiency in a common environment, thereby attracting students who are studying or intending to study majors close to the semiconductor industry as well as students who are interested in the industry register to major in semiconductors.

Fourth, businesses need to build an attractive and friendly working environment, such as attractive welfare policies, including comprehensive health insurance and recreational activities, to enhance employee satisfaction and commitment. At the same time, create an open working environment, encourage creativity and innovation, establish awards or programs to encourage employees to contribute new ideas and implement technology innovation projects.

Fifth, universities need to establish output standards of training programs for high-quality personnel. Focus on investing in facilities according to the requirements of the training program to be able to carry out the training; the output standards of the training program must follow international standards to be able to meet the needs not only domestically but also internationally. Determine the output of high-quality human resources right from the beginning of training to ensure there is no waste of effort for both the training unit and the trained person. This is very important because if we only talk in general terms, it is difficult to determine the exact training according to the needs of society. After determining the exact field that needs training to meet the needs of companies, it is necessary to learn about training methods, certificates and training methods to meet the needs - thereby finding high-quality employees - teachers and lecturers - to be able to meet this need.

Sixth, it is necessary to promote cooperation between higher education institutions and businesses that need to use human resources and localities where businesses are investing or will invest to share vision and experience, long-term, sustainable development orientation, and optimization of resource use in the semiconductor industry. Vietnam needs to create an ecosystem that attracts many companies, from commercial enterprises to technology companies and educational and training institutions, to create an environment of development and contribute to the socio-economic development of Vietnam. On the other hand, internally, within training facilities and universities, it is necessary to improve the capacity of lecturers and experts serving training and research. Training institutions also need to cooperate with the State in investing in upgrading facilities to improve training quality to meet the strict requirements of domestic and foreign businesses, helping students have a favorable environment—the best learning access to modern technology.

Seventh, the State should have policies to support and associate with training institutions and businesses in forming chip design training centers, organizing training courses for lecturers, students and support software copyrights, training programs, granting scholarships to universities, organising short-term training programs for lecturers, students, and engineers in the field who wish to participate in the transition to the semiconductor industry to create a premise for implementing high-quality human resource training activities in the field of microchips.

V. CONCLUSION

The semiconductor chip shortage crisis in recent years has "paralyzed" production lines in some countries. In that context, the semiconductor chip industry in Southeast Asia emerges as a solution, and Vietnam is expected to become the focus of the global semiconductor value investment chain. Although it is considered to be able to bring in billions of dollars in revenue, the semiconductor chip industry in Vietnam still faces many challenges, especially due to the lack of human resources. The study pointed out the current human resource shortage in the semiconductor industry in Vietnam and the challenges and lessons learned from Taiwan, the leading Asian country in the semiconductor industry. From there, the research team proposed a number of policy implications to improve the quantity and quality of human resources for the semiconductor industry in Vietnam.

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